Optimizing Canola Production:
Pest Implications of Intensive Canola Rotations

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ABSTRACT

Flexibility in rotation planning allows canola and field pea producers to adapt to changing management practices and marketing opportunities. Current recommendations are to follow a one in four year rotation for canola or field pea on a particular field. The objective of this study was to determine the consequences of more intensive rotations of these crops using current technology: disease resistant, herbicide tolerant varieties and new fungicides for disease control. The study was conducted at Scott and Melfort, SK, which represents the range of climatic variation in the parkland area of the prairies. A four replicate split-plot experiment was established at each site with treatments that consisted of rotations of continuous canola and field pea to rotations that contained these crops every 2-, 3-, and 4-years with wheat and flax. Two varieties of canola were included, an herbicide tolerant, blackleg resistant hybrid (Invigor 5030 or 5020) and an open-pollinated, blackleg susceptible conventional herbicide type (Westar). Sub-plots were fungicide treatments where we attempted to control sclerotinia stem rot in canola and mycosphaerella blight in field pea. Blackleg of canola and mycosphaerella blight of field pea, were the major pest problems that occurred in all years. These diseases, as well as the prevalence of weeds, were greater in more intensive rotations of canola and field pea. In canola, the use of a blackleg resistant variety in a 4-year rotation provided the most effective disease control. Yield of both canola varieties increased with length of rotation, although there was little difference among rotations of 2 or more years for Invigor varieties, but yield of Westar continued to increase as the frequency in rotation decreased to once in four years. Yield of field pea was reduced in the continuous rotation compared to other rotations, but the difference among rotations of 2 or more years was small. Fungicide application resulted in an 11-16% yield increase of field pea at some site-years, and an increase of 48% at one site-year, but no yield increase at other site-years. Fungicide application did not increase yield of wheat at either location in 2004 or 2006, but did result in a 27% yield increase at Scott and a 13% increase at Melfort in 2005. Yield and sometimes quality of wheat were reduced when wheat was grown on Invigor canola stubble compared to Westar stubble. This is an indication that wheat crops following highly productive canola crops, such as the Invigor varieties used in this study, may require greater levels of fertility than wheat grown after less productive canola crops. The results clearly indicate the importance of crop rotation to manage diseases and weeds of canola and field pea, and for the former, the importance of genetic resistance in the control of blackleg.

INTRODUCTION

In many years canola provides the best economic return to producers compared to other field crops grown in western Canada. For this reason production of canola is often intensive, meaning it is grown more than once every four years on the same field. Producers and industry need to understand the consequences of intensive canola rotations in order to prepare for unwanted outcomes such as pest problems. In Europe, Christen and Sieling (1995) found that diseases, particularly blackleg [*Leptosphaeria maculans* (Desmaz.) Ces. & De Not.], were a major cause of yield decrease of oilseed rape in short rotations. In that study the greatest canola yields occurred on field pea stubble followed by production on cereal stubble and the poorest production was on oilseed rape stubble. Blackleg has been observed to be one of the most common diseases of canola in western Canada (Pearse et al. 2004). Also in western Canada, crop sequence research has indicated that more diverse rotations tended to have less pest problems and lower production risk than rotations that were heavily cereal or broadleaf based (Johnston et al. 2005).

The recommendation to grow canola or field pea only once every four years is based primarily on the need to manage disease and weed pests. Growers frequently question whether improved weed control technology and varieties with improved disease resistance can overcome these limitations. To address this question this study compared a recommended 1 in 4-year crop rotation of canola and field pea with more intensive production of these crops in rotation with wheat and flax. The impact of fungicides was also examined within these rotations. To demonstrate the improvements made in canola technology since the original recommendation to grow canola only once in a four year rotation, a variety representing the latest technology (herbicide tolerant, blackleg resistant, hybrid) was compared with a variety that was commonly grown when this recommendation was made (conventional, open-pollinated, blackleg susceptible).

The objective of this study was to determine the implications of intensive production of canola and field pea, while considering the variety and pesticide improvements that have been made since the one in four year rotation was recommended. Related to this, the study also evaluated how the frequency of canola and field pea in the rotation impacted disease and weed control and yield losses due to weeds as the basis for developing revised crop rotation recommendations for canola and field pea. This study was a continuation of a previous 5 year trial, discussion of which can be can be found in the final 5-year report for the study submitted to the Saskatchewan Canola Development Commission Growers in March, 2004. Yield results of all years are summarized in Appendix 2.

MATERIALS & METHODS

The study was conducted at Scott and Melfort, SK, which represent the Moist Dark Brown and the Moist Black soil zone. The experiments were established in 1998 at Scott, SK and in 1999 at Melfort, SK. Field experiments were designed as 4 replicate split-plots of seven rotations with all phases of each rotation present every year. Length of rotations and abbreviations used to describe each rotation are provided (Table 1), and where a specific phase of the rotation is referred to that phase is capitalized, for example the wheat phase of canola wheat would be denoted as c-W. Fungicides were applied to sub-plots of each crop. Rotations with canola had variety as an additional factor.

Table 1. Rotation lengths (years), abbreviations and descriptions.

Rotation Length	Rotation Abbreviation	Rotation Description
continuous	C	canola
continuous	P	pea
2	c-w	canola-wheat
2	p-w	pea-wheat
3	p-c-w	pea-canola-wheat
4	c-w-p-w	canola-wheat-pea-wheat
4	c-w-f-w	canola-wheat-flax-wheat

Canola varieties were a conventional herbicide, blackleg susceptible variety (Westar) and a herbicide resistant hybrid with improved blackleg resistance (Invigor 5030 in 2004, Invigor 5020 in 2005, 2006 and 2007). The field pea varieties CDC Mozart (2004) and Eclipse (2005 and 2006) were grown at Melfort and at Scott the variety Eclipse was grown in all 4 years, both varieties are resistant to powdery mildew (*Erysiphe pisi* Syd.). Included in the rotations were AC Intrepid wheat at Melfort and AC Eatonia wheat at Scott in all years of the study. Bethune flax was used in all years at both locations.

The study was conducted under conservation tillage and used best management practices to optimize crop production at each location. All crops were seeded with a Conserva

Pak drill set at a 9-inch row spacing at Melfort, and with a Versatile hoe drill with a 10-inch row spacing at Scott. Target seed rates were 100 to 160 seeds m^{-2} for field pea and 160 seeds m^{-2} (~7 kg ha^{-1}) for canola at both sites, in all years. At Melfort, canola and field pea were fertilized with 100 kg ha^{-1} of 14-20-10-10 side-banded and in addition for canola, urea (46-0-0) was side-banded at 112, 144 and 184 kg ha^{-1}, in 2004, 2005 and 2006, respectively. Soils tests indicated residual soil nitrogen (N) of 62, 40 and 22 kg ha^{-1}, at Melfort in 2004, 2005 and 2006, respectively. At Scott in 2004, 2005 and 2006, 67 kg ha^{-1} of 12-51-0 was side-banded at seeding with canola and in addition 52 (2004), 65 (2005) and 129 (2006) kg ha^{-1} of urea was mid-row banded. Residual soil nitrogen at Scott was 77, 73 and 30 kg ha^{-1}, in 2004, 2005 and 2006, respectively.

Weed control was achieved with a pre-seed burn-off for canola and field pea with 450 and 178 g.ai. ha^{-1} of glyphosate (Round-Up Transorb, Monsanto) in 2004 and 2005, respectively and with 270 g.ai. $ha^{-1}$of glyphosate (Touchdown I.Q., Syngenta) in 2006. For Westar canola, granular ethalfluralin (Edge, Dow AgroSciences) was fall applied at 1.4 kg. ai. ha^{-1} every year, and sethoxydim (Poast Ultra, BASF) at 106 g.ai. ha^{-1} and ethametsulfuron-methyl (Muster Toss-N-Go, Dupont) at 22 g.ai. L^{-1} applied post-emergence in 2004. In 2005 and 2006, a tank mix of sethoxydim (Poast Ultra®, BASF) at106 g.ai. ha^{-1}, ethametsulfuron-methyl (Muster Toss-N-Go®, Dupont) at 22 g.ai. L^{-1}, and clopyralid (Lontrel®, DowAgroSciences) at 302 g.ai. ha^{-1} were applied post-emergence. Glufosinate ammonium (Liberty, Bayer) at 405 g. ai. ha^{-1} was applied in-crop to the Invigor variety in 2004 and in both 2005 and 2006 clethodim (Select®, Arvesta) at 89 g.ai. ha^{-1}, was applied in addition to the glufosinate. Ethalfluralin (Edge®, Dow AgroSciences) at 1.4 kg. ai. ha^{-1} was fall applied to field pea plots and metribuzin (Sencor 75DF, Bayer) at 143 g.ai. ha^{-1}, MCPA sodium salt at 140 g.ai ha^{-1}, and sethoxydim (Poast Ultra®, BASF) at 211 g.ai. ha^{-1} were applied in-crop. In wheat at Melfort, florasulam at 5 g.ai. ha^{-1} and MCPA ester at 346 g.ai. ha^{-1} (Frontline®, Dow AgroSciences) and fenoxaprop-p-ethyl (Puma Super®, Bayer CropScience)at 92 g.ai. ha^{-1} were applied. In wheat, at Scott, clodinafop-propargyl (Horizon®, Syngenta) at 56 g.ai. and bromoxynil and MCPA ester (Buctril M, Bayer CropScience) at 277 g.ai. ha^{-1} (each active ingredient) were applied, except to wheat seeded on flax stubble where fluroxypyr at 107 g.ai. ha^{-1} and 2,4-D LV ester at 557 g.ai. ha^{-1} (Attain®, Dow AgroSciences) were applied. Flax was sprayed with bromoxynil and MCPA ester (Buctril M, Bayer CropScience) at 277 g.ai. ha^{-1} (each active ingredient) and sethoxydim (Poast Ultra®, BASF) at 211 g.ai. ha^{-1}.

The fungicide boscalid (Lance, BASF) was applied to split-plots of canola at 246 g. ai. ha^{-1} at 20-30% bloom to control sclerotinia stem rot at both locations in all years, except at Scott in 2004, where azoxystrobin (Quadris, Syngenta) was applied at 125 g. ai. ha^{-1} at 20-30% bloom. Pyraclostrobin (Headline, BASF) at 99 g.ai ha^{-1} was applied to field pea at early flower, wheat at flag leaf stage (148 g.a. ai ha^{-1}) and flax during flowering (99 g.ai. ha^{-1}). All fungicides were applied in 100 L ha^{-1} of water. Canola seed of both varieties was treated with thiamethoxam, difenconazole, metalaxyl and fludioxonil (Helix, Syngenta). At Scott, an application of deltamethrin (Decis®, Bayer CropScience) at 6.2 g. ai. ha^{-1} was applied to canola during flowering to control diamondback moth larvae in 2005 only.

Pre-harvest weed and crop biomass yields were bulked from 2 row widths (23 cM) by 1 metre at 2 locations in fungicide untreated plots of canola and field pea at Melfort. At Scott the pre-harvest weed and crop biomass yields were bulked from 2 row – ¼ m^{-2} samples collected at 2 locations within each fungicide split for canola and field pea. Biomass yields were measured indirectly from a representative sub sample dried at 60^{o}C for 24 hours and weighed. At both, Melfort and Scott, canola and field pea were swathed and then combined, while wheat and flax were straight combined, except at Melfort in 2006 where flax was swathed, then combined.

To evaluate disease severity various published and modified scales were used based on disease and crop type (Appendix 1). Higher values in all scales represent increased severity. Canola disease assessment at swathing (30% seed colour change) was conducted on 100 plants/plot using a 0-5 scale for blackleg severity (Newman, Appendix 1) as well as recording disease incidence (% of plants infected) for both blackleg and sclerotinia stem rot. Foliar and stem assessments were conducted on 10 plants per plot for mycosphaerella blight (*Mycosphaerella pinodes* (Berk. & Blox.) Vestergr.; *Phoma medicaginis* Malbr. & Roun. in Roun. var. *pinodella* (L.K. Jones) Boerema) near physiological maturity (plant dry down) using two different 0-9 scales (Xue and Wang scales, Appendix 1) that assessed the severity of infection of leaves, stems and pods. Wheat was assessed for leaf spot diseases on the flag and penultimate leaves using a 0-11scale converted to a percentage leaf area infected (Horsfall and Barratt 1945) and using a whole plant evaluation scale (0-11, McFadden et al. 1991, Appendix 1).

RESULTS AND DISCUSSION

Climatic conditions

Climatic conditions during the years of this study provided a good balance to the previous 3 years of the first study (2001-2003), which were characterized by dry to extremely dry conditions. Generally, precipitation was close to or above long-term normals at both Scott and Melfort from 2004 to 2006 (Table 2). Average temperatures were cooler than normal during the growing seasons in 2004 and 2005 at both locations and above long term normals at both locations in 2006. Unfortunately an August frost in 2004 had an impact on the experiments, as well as hail storms at Scott in both 2005 and 2006. Hail at Scott during 2005 occurred July 12 and caused extensive damage at the time. However with good moisture, crops recovered reasonably well and at harvest it was difficult to determine the extent of yield loss. During 2006, hail occurred August 4, when most crops were nearing maturity. Yield loss was extensive, and we attempted to measure it to estimate yield in the absence of hail. Field pea was near maturity, and most loss was as a result of pods being shattered. To estimate yield loss, the numbers of seeds m^{-2} were counted after harvest in each plot, and mean seed weight on 100 seeds from each plot was determined and yield calculated. For other crops we measured damaged stems and tillers, heads and pods at several locations in the trial to estimate the extent of loss. Results were compared with estimates on similar crops in adjacent commercial fields by hail adjusters to ensure that estimates were reasonable. On that basis we estimated loses in wheat and flax at 60%, and in canola at 80%. A commercial canola field immediately west was estimated at 100% loss, and a wheat field immediately south was estimated at 75 percent loss.

Canola

Plant population

Canola plant populations exceeded the 40-60 plants m^{-2} considered essential (Brandt et al. 2007) to support optimum yield with both varieties at all location years (Table 3), except at Scott in 2006. At this site-year, low plant densities likely reflected cool soil conditions that were experienced shortly after seeding, but other factors may have limited seedling establishment, like excessively deep seeding. Plant densities were significantly higher in continuous C than some other rotations for Westar at Scott in all years, higher for Invigor at Scott in 2005, and tended to be higher for Westar at Melfort in 2004. This indicated the presence of volunteer canola plants from the preceding canola crop although the results are insufficient to conclude that the 2 varieties differ in their capacity to generate volunteers the following year.

Weed to Crop Biomass Ratio

The ratio of the biomass of weeds to crop plants, described as a percentage, tended to be lowest for p-C-w, C-w-p-w, and C-w-f-w with both varieties (Table 4). At Melfort in 2005, weed biomass was significantly higher in continuous C for both varieties than in the 3 or 4 year rotations. At Scott in 2004, weed biomass was significantly higher in C-w where Westar was grown, and where Invigor was grown at Melfort in 2006. Overall weed biomass was relatively low in all rotations each year, and weeds not fully controlled by herbicides likely had minimal impact on yield at most site-years.

Disease impact

Sclerotinia stem rot was observed at Melfort in most years, but only at very low levels (<3% disease incidence). The level of sclerotinia observed at Scott was even lower and in 2005 the disease was not observed. Fungicide was applied to split-plots to control sclerotinia stem rot. However, since there was virtually no sclerotinia, any impact of the fungicide was obviously not due to disease control. As will be discussed below, there were occasionally differences among fungicide treatments for other factors such as yield, possibly due to physiological effects of the fungicide on the crop, but not due to sclerotinia control.

Blackleg of canola was the most significant disease observed at either Scott or Melfort throughout the study. The incidence and severity of blackleg in the susceptible canola variety, Westar was moderate to high relative to Invigor at all site-years. Significant differences were observed among rotations for the incidence and severity of blackleg at Melfort in 2005, both locations in 2006, and Scott in 2007. At all site-years, except Scott, 2005, where disease evaluation was difficult due to hail damage, the trend was to lower impact of blackleg as length of rotation increased. Blackleg incidence and severity in rotations of Invigor canola at all site-years tended to be low to moderate, and no significant differences among rotations were detected in either 2004 or 2005 (Tables 5 and 6). However, at Scott in 2006 and 2007, both the incidence and severity of blackleg in Invigor canola was greater in the continuous C rotation than other rotations. At Melfort in 2006, blackleg incidence and severity were significantly lower in the 4-year rotations than in shorter rotations, including the 3-year rotation. While not significant, this trend was observed at both locations in the previous years, 2004 and 2005.

Differences for blackleg disease symptoms between varieties indicate the effectiveness of genetic resistance in combating this disease. At all site-years, the Invigor varieties were always much less affected by the disease as indicated by lower incidence and severity ratings than that of Westar canola. While the incidence of blackleg infection of Invigor canola was sometimes moderate, i.e. continuous C rotation at both locations in 2006 (Table 5), the severity of the disease was relatively low (<0.8 on a scale of 5). Equally important for the control of this pathogen is the length of rotation. Rotations of 4-years resulted in significantly lower blackleg incidence and severity than the 3-year rotation of Invigor canola at Melfort, 2006, and although statistically insignificant, this trend was observed at both locations for Invigor canola in 2004, and at Scott in 2006 and 2007. The same trend was observed for Westar canola at both locations in 2006. Continuous C and 2-year rotations of either variety generally had greater incidence and severity of blackleg than 4-year rotations and sometimes the 3-year rotation. The increase in disease incidence and severity of blackleg with rotations shorter than 4 years results in an increase of infected canola residue, which can contribute to greater pathogen inoculum in future years and therefore to greater potential infections of future crops.

Grain yield

Fungicide had little impact on yield (data not shown), but several inconsistent responses to fungicide were noted. They included: fungicide increased Westar yield in C-w-p-w and decreased it in p-C-w at Scott in 2004; fungicide increased Invigor yield in C-w at Scott in 2006; fungicide increased Westar yield in p-C-w but decreased Invigor yield in most rotations at Melfort in 2004; and decreased Westar yield in C-w-f-w at Melfort in 2005. As discussed above, since there was virtually no sclerotinia stem rot disease pressure in any year and at either site, these effects of fungicide may have been due to physiological effects on the crop or simply random.

As expected, yield of the hybrid variety (Invigor) was consistently higher than yield of Westar. The yield advantage varied somewhat among site-years, but averaged 44 percent higher over all comparisons. Yields were similar for the 3-year (p-C-w) and 4-year rotations (C-w-p-w and C-w-f-w) of both varieties, although yield of Invigor at Melfort in 2005 and Scott in 2007 was lower for the C-w-f-w rotation than for p-C-w. Yield was typically lowest for the continuous C rotation, although at 4 of 7 site-years for Invigor canola and 6 of 7 site-years for Westar the C-w rotation was statistically insignificant from the continuous C rotation. Averaged over all site-years, the yield loss associated with growing Invigor canola continuously compared to every second year (2-year rotation) was 23%, or every third year was 35%. For Westar averaged over all site-years, yield reduction of the continuous canola rotation compared to the 2-year rotation was 13% and compared to the 3-year rotation was 44%, although yield of Westar was lower than Invigor for all rotations. The greater percentage yield loss of Westar than Invigor, due to shortened rotations indicates the greater blackleg susceptibility of Westar.

Many currently grown canola varieties, which are assessed as moderately resistant to blackleg, would be expected to fall between the values for the Invigor varieties and Westar obtained in this study.

The 3-year rotation (p-C-w) of Invigor canola was slightly higher in yield than the 4-year rotations when averaged over all site-years, although this was statistically significant only at Scott in 2006. This reflected the benefit of growing the crop on field pea stubble and the reduced impact of blackleg compared to shorter rotations. In the 4-year rotations, canola was grown on wheat stubble and therefore did not benefit from the added nitrogen or moisture provided by the previous field pea crop. However, for Westar canola blackleg incidence and severity was likely responsible for the fact that yield was reduced in the 3-year rotation compared to the 4-year rotations, despite the benefit of the previous field pea crop in the 3-year rotation.

Over all site-years, Westar canola yield was 31% lower in continuous C and 23% lower in C-w than in C-w-f-w, while in p-C-w and C-w-p-w, Westar yield averaged within 4% of C-w-f-w. By contrast, Invigor yield was only reduced by 16% when grown continuously, and was, on average equal to C-w-f-w when grown in C-w. Invigor yield in p-C-w was 11% higher than in C-w-f-w, while Invigor yield of C-w-p-w was 6% greater than C-w-f-w. Yield results would suggest that the improved variety has made modest progress, but certainly has not overcome the need for rotation in optimizing canola yield.

Test weight, TKW, green seed and oil content

Rotation and variety generally had small and inconsistent effects on test weight (Table 8), as did fungicide (data not shown). Effects on test weight were generally considered to be of minimal practical significance, and did not help to explain other treatment responses. Seed weight was sometimes reduced in continuous C compared with rotations where canola was grown less frequently (Table 9), and on one occasion, seed weight in the C-w rotation was also reduced. Such reductions in seed weight have limited impact in commercial canola production. However, seed size can affect early seedling growth and vigour of canola grown for seed, and smaller seed size may be an indicator that seed filling has been hampered by disease or other forms of biotic or abiotic stress. The amount of green seed that was present in the seed sample varied from year to year or between Scott and Melfort as a result of climatic conditions, i.e. hail likely delayed seed maturation in 2005 and 2006 at Scott (Table 10). However, there was little variation among rotations. Similarly for oil content, there was inconsistent variation among rotations (Table 11). Oil content of Westar canola at Melfort, 2004 was lower in the continuous

C rotation than the 4-year rotation with flax, but the reverse was observed for Invigor canola at Melfort in 2005. Invigor had greater oil content than Westar canola at Scott in 2005 and 2006.

Field Pea

Plant population

Seeding rate among years and locations had the greatest impact on plant density of field pea (Table 12). There was little difference among rotations for field pea plant density, which always appeared more than adequate. The lack of differences among rotations for plant population indicated that field pea does not over-winter to any extent.

Weed/Crop Biomass

The ratio of weed to crop biomass, a measure of the impact of weeds on the crop was low and did not vary among rotations at Scott or Melfort in 2004 (Table 12). At Melfort in both 2005 and 2006, the greatest weed/crop biomass ratio was observed in the continuous P and 3-year rotations (statistically significant only in 2006). Weed biomass in the continuous P at Melfort was mainly cleavers (*Galium aparine* L.) in 2005, and in 2006 this species dominated the continuous pea plots (Figure 1). This reflected the difficulty of controlling certain weed species with conventional herbicides in continuous pea, but there is no ready explanation for greater weed biomass in p-c-w.

Figure 1. Cleavers in the continuous field pea rotation at Melfort in 2006.

Disease impact

Mycosphaerella blight was the predominant disease that occurred in field pea and was observed every year, although the severity of the disease was much greater in 2004 than in other years at both Scott and Melfort (Table 13). Results were similar for both the Xue disease assessment scale, which measures the severity of symptoms on all the foliage (leaves, stems and stipules) and the Wang scale, which measures the degree of lower stem infection only. Differences among rotations were detected at Melfort in 2004 and in 2006, where the disease severity was greater in the continuous P rotation than in other rotations. Differences among rotations in other years at either Scott or Melfort were not observed. Fungicide was effective at reducing disease severity at both Scott and Melfort in 2004, at Scott in 2006 (Xue scale) and Melfort in 2006 (Wang scale).

Seed yield

Seed yield of field pea tended to be lower in the continuous P rotation than in other rotations, which did not differ significantly from each other (Table 14). Only at Scott in 2006, was this trend not observed. However, this site-year sustained severe hail damage, which may have account for this difference from other site-years. Averaged over all site-years and fungicide treatments, the yield reduction of continuous P compared to the 2-, 3- and 4-year rotations were 28%, 31% and 35%, respectively. These results indicate that rotation is effective for the control mycosphaerella blight in field pea, although there was limited difference in yield among rotations of 2- to 4-years. The lack of difference among rotations of 2 or more years is likely due to the highly airborne dispersal of mycosphaerella inoculum among plots and growers fields, and may also reflect the presence of increased root diseases in the continuous P rotation compared to other rotations, although only limited fusarium infection of roots was detected during the study (data not shown). The presence of significant weed biomass also contributed to reduce pea yield in the continuous P rotation at Melfort in 2006.

Fungicide increased yield at Scott 16% in 2004 and 11% in 2006 and was very effective in increasing field pea yield in 2004 at Melfort (48%) and in 2005 at Scott (126%). Disease severity was very high at Melfort in 2004 since maturity was delayed by 2 to 3 weeks by cooler than normal summer temperatures (Table 2). At Scott, 2005, hail damage likely resulted in a greater impact of the pathogen, and therefore greater augmentation in yield due to the fungicide, although yield was low for both treatments as a result of the hail damage. Statistically, there was no yield benefit to application of fungicide at Melfort in 2005 and 2006, or at Scott in 2007.

Test weight, thousand seed weight and protein content

Test weight varied among rotations inconsistently over site-years (Table 15). It was greater in the continuous P rotation than other rotations at Melfort in 2004 and Scott in 2006, but lower in continuous P than other rotations at Melfort in 2006. Fungicide increased test weight at Melfort, 2004 and 2005, and at Scott, 2005. Thousand seed weight also varied inconsistently among rotations over site-years (Table 16). It was lower in continuous P at Melfort in 2005 and 2006, but greater in continuous P than other rotations at Scott in 2006. Fungicide increased TSW at both Scott and Melfort in 2004 and at Scott in 2005. Protein content did not vary among rotations at any site-year except Melfort, 2005, where it was slightly greater in the continuous pea rotation than other rotations (Table 17). Protein content was reduced with the application of fungicide at both locations in both 2004 and 2005, but not at either location in 2006.

Wheat

Disease impact

Leaf spot severity of wheat, caused by Septoria species and tan spot were assessed on the whole plant and on the flag and penultimate leaves at Melfort only. Wheat was included in the each of the rotations every second year, except for the 3-year rotation. Therefore it was not surprising that there was no difference among rotations for disease severity of either the whole plant or the upper leaves (Table 18). Fungicide had a significant impact and reduced leaf spot severity in all years at Melfort.

Grain yield and quality

During 2004, rotation and fungicide did not affect wheat yield at Scott (Table 19), but at Melfort, wheat following pea or flax yielded more than where wheat followed canola with one exception. Wheat following canola in the p-c-W rotation provided intermediate yield. At Scott in 2005, fungicide increased yield in all rotations by an average 27% compared with no fungicide. A similar trend was observed at Melfort in 2005, although the effect of fungicide was not statistically significant for the p-W and c-W-f-w phases due to the high variability of the data. Yield increased an average of 13% over all rotations when fungicide was applied at Melfort in 2005. Difference among rotations or fungicide treatments was not observed for wheat yield at either Scott or Melfort in 2006, reflecting the reduced severity of leaf spot infection in 2006 compared to previous years, at least at Melfort (Table 18). There was no yield benefit to fungicide application at Scott in 2007, but yield of wheat was greater in the 4-year rotation when the wheat followed field pea than in all other rotations, except the 4-year rotation where wheat followed flax.

The impact of the preceding canola variety on yield and quality of wheat was also examined at Scott and Melfort (Table 18). Differences in yield of wheat when grown after Westar or Invigor canola were not observed at either site in 2004 or 2006. During 2005 at both locations, wheat yield was higher following Westar than after Invigor canola, which likely reflected greater nutrient and/or moisture removal by the higher yielding hybrid variety.

Test weight of wheat was greater following Westar than Invigor canola at Melfort in 2005, but the opposite occurred at Scott in 2006 and differences were not detected at other site-years (Table 20). Test weight of wheat varied among rotations and phase in each rotation. It tended to be higher in rotations or phases where it followed field pea or flax (p-W, p-W-c-W and c-w-f-W) than where it followed canola, such as at Scott in 2004 (Table 21). However, this was not observed in other years although there were differences among rotations for test weight at Melfort in 2005 and 2006, and at Scott 2006. Fungicide tended to increase test weight, but varied with rotation and phase. Averaged over all rotations and phases at Scott, 2005 and 2007, and at both Scott and Melfort, 2006, fungicide application resulted in increased test weight.

Seed weight of wheat did not vary among the rotations except at Scott in 2007 (Table 22), where it was somewhat greater in the 4-year rotation following field pea than in other rotations. This was similar to the results for yield and test weight for Scott in 2007. At 3 site-years, Scott, 2005 and 2007, and Melfort 2005, application of fungicide resulted in greater seed weight.

Protein content of wheat was observed to differ by 0.2% and by 0.9% between rotations of Westar and Invigor canola, with less protein following Invigor than following Westar at Melfort in 2004 and 2005, respectively (Table 20). This result suggests that reduced N after the higher yielding hybrid variety played a role in reduced protein content of wheat at these site years. Protein content varied among rotations and phases at Scott, 2005 and Melfort 2005 and 2006 (Table 21). Generally protein content was greater in rotations that included field pea than in rotations that did not. Fungicide application had little impact on protein content, except at Scott, 2005 where averaged over all rotations and phases, it increased by 0.2%.

Flax

Flax was included in a 4-year rotation in this study (canola-wheat-flax-wheat). The main disease observed was pasmo. Fungicide applied in the split-plot did not result in statistically significant yield increases or differences in test weight (Tables 24 and 25).

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LITERATURE CITED

Brandt, S. A., Malhi, S.S., Ulrich, D., Lafond, G.P., Kutcher, H.R and Johnston, A.M. 2007. Seeding rate, fertilizer level and disease management effects on hybrid versus open pollinated canola (*Brassica napus* L.). Can. J. Plant Sci. 87: in press.

Christen, O. and K. Sieling. 1995. Effect of different preceding crops and crop rotations on yield of winter oil-seed rape (*Brassica napus* L.) J. Agronomy and Crop Science. 174:265-271.

Horsfall, J.G. and R.W. Barratt. 1945. An improved grading system for measuring plant diseases. Phytopathology 35:65 (abstract).

Johnston, A.M., H.R. Kutcher and K.L. Bailey. 2004. Impact of crop sequence decisions in the Saskatchewan Parkland. Can. J. Plant Sci. 85:95-102.

McFadden, W. 1991. Etiology and epidemiology of leaf spotting diseases in winter wheat in Saskatchewan. Ph.D. thesis, University of Saskatchewan, Saskatoon, 151 pp.

Newman, P.L. 1984. Differential host-parasite interactions between oilseed rape and *Leptosphaeria maculans*, the causal fungus of stem canker. Plant Pathology 33:205-210.

Pearse, P. R.A.A. Morrall, H.R. Kutcher, J.M. Yasinowski, C.L. Harris, R.K. Gugel, and K. Bassendowski. 2004. Survey of canola diseases in Saskatchewan, 2004. Can. Plant Dis. Surv. 84:74-75.

Wang, T.F. (Ting-Fu). 1998. Evaluation of mycosphaerella blight resistance in pea. M.Sc.Thesis. University of Saskatchewan, Saskatoon. 129 pp.

Xue, A., T.D. Warkentin, M.T. Greeniaus and R.C. Zimmer. 1997. Genotypic variability in seedborne infection of field pea by *Mycosphaerella pinodes* and its relation to foliar disease severity. Canadian Journal of Plant Pathology 18:370-374.

Table 2. Monthly precipitation and mean monthly temperatures at Scott and Melfort from 2000-2007; long term averages from 1971-2000.

Month	Precipitation (mm)										Temperature (Celsius)								
	2000	2001	2002	2003	2004	2005	2006	2007	Long Term		2000	2001	2002	2003	2004	2005	2006	2007	Long Term
										Scott									
Previous Sept-Apr	116	106	65	131	120	147	196	202	147										
May	24	18	4	20	35	41	63	79	36		9.4	11.0	8.0	10.1	8.0	9.0	10.9	11.0	10.9
June	41	59	62	35	52	100	46	103	63		13.5	13.9	16.4	14.9	12.7	13.5	15.3	14.0	15.2
July	91	37	39	57	69	77	35	14	71		17.8	17.7	19.3	17.7	16.7	18.0	18.8	21.0	17.0
August	57	4	46	36	44	88	47	36	43		15.6	19.0	15.6	19.6	14.0	13.0	16.3	14.0	16.3
Growing Season Total	213	118	151	148	200	306	191	232	213	Mean Temp °C	14.1	15.4	14.8	15.6	12.9	13.4	15.3	15.0	14.9
Annual Total†	329	224	216	279	320	519	387	434	359										
										Melfort									
Previous Sept-Apr	102	102	95	176	147	150	240	274	169										
May	15	9	4	45	18	43	63	74	48		9.1	11.6	6.8	12.5	6.7	8.6	13.3	10.6	10.8
June	74	23	63	64	71	177	74	119	73		13.0	14.0	17.1	15.9	12.5	13.9	18.2	14.4	15.7
July	106	46	5	36	56	70	112	47	77		17.6	18.4	19.8	18.0	16.5	16.9	17.8	20.1	17.4
August	47	11	129	24	55	97	46	40	58		16.6	19.0	16.0	19.9	13.6	14.9	18.3	14.7	16.4
Growing Season Total	242	89	201	169	200	387	295	280	256	Mean Temp °C	14.1	15.8	14.9	16.6	12.3	13.6	16.9	15.0	15.1
Annual Total†	344	191	296	345	347	537	535	554	425										

† annual total precipitation from Sept 1 or previous year to August 31st of each year.

Table 3. Plant populations [plants m^{-2}] in rotations with Invigor and Westar canola at Scott and Melfort SK. during 2004, 2005 and 2006.

Rotation	2004				2005				2006			
	Scott		Melfort		Scott		Melfort		Scott		Melfort	
	Invigor 5030	Westar	Invigor 5030	Westar	Invigor 5020	Westar	Invigor 5020	Westar	Invigor 5020	Westar	Invigor 5020	Westar
Continuous C†	76	103 a	113	126	169 a	187 a	109	61 c	52	42 a	95 a	96
C-w	63	53 b	126	106	134 b	103 b	115	65 bc	38	31 ab	93 ab	87
p-C-w	135	86 ab	128	109	133 b	162 a	119	82 ab	50	27 b	110 a	102
C-w-p-w	75	75 ab	131	106	115 b	130 ab	111	96 a	37	22 b	102 a	75
C-w-f-w	115	92 ab	124	105	109 b	139 ab	112	97 a	31	31 ab	72 b	76
LSD $_{(0.05)}$	100	47	37	23	30	54	28	20	31	13	22	34
Mean	93	82	124 a	110 b	132	144	113 a	79 b	41 a	301 b	94	87
LSD $_{(0.05)}$	31		13		20		11		89		13	

† C - canola, P – field pea, W – wheat, F – flax.

Table 4. Weed to crop biomass ratio [%] in rotations with Invigor and Westar canola at Scott (2004) and Melfort (2004-2006).

Rotation	2004				2005		2006	
	Scott		Melfort		Melfort		Melfort	
	Invigor 5030	Westar	Invigor 5030	Westar	Invigor 5020	Westar	Invigor 5020	Westar
Continuous C†	0.2	3.1 b	7.4	7.8	5.0 a	3.0 a	2.1 b	7.7
C-w	1.9	34.0 a	5.4	3.6	2.0 ab	1.0 b	19.9 a	4.9
p-C-w	0	0.1 b	1.7	0.2	0 b	0.3 b	0.1 b	4.6
C-w-p-w	0	2.9 b	4.4	1.6	0.1 b	0.5 b	6.8 b	1.4
C-w-f-w	0	0.9 b	1.9	2.8	0 b	0.1 b	5.9 b	2.2
LSD $_{(0.05)}$	2.5	21.2	9.3	8.1	3.2	1.9	13.1	8.2
Mean	0.4 b	8.2 a	4.1	3.2	1.4	1.2	7.0	4.2
LSD $_{(0.05)}$	6.4		3.6		1.4		5.3	

† C - canola, P – field pea, W – wheat, F – flax.

Table 5. Blackleg incidence [%] in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 -2007.

Rotation	2004				2005			
	Scott		Melfort		Scott		Melfort	
	Invigor 5030	Westar	Invigor 5030	Westar	Invigor 5020	Westar	Invigor 5020	Westar
Continuous C†	3.3	39.3	16.9	82.0	26.8	59.8	.	32.9 a
C-w	0.4	29.5	5.2	70.2	18.8	65.0	.	33.5 a
p-C-w	9.5	28.8	12.5	84.7	8.5	56.5	.	14.0 b
C-w-p-w	0	30.3	4.7	66.4	9.8	59.8	.	15.1 b
C-w-f-w	1.1	28.8	4.9	70.1	10.3	66.5	.	19.8 b
LSD $_{(0.05)}$	13.1	13.6	7.4	12.9	11.8	16.8	.	10.5
Mean	2.9 b	31.3 a	8.9 b	74.7 a	14.8 b	61.5 a	.	23.1
LSD $_{(0.05)}$	4.4		6.4		6.5			

† C - canola, P – field pea, W – wheat, F – flax.

Table 5 continued. Blackleg incidence [%] in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 - 2007.

Rotation	2006				2007	
	Scott		Melfort		Scott	
	Invigor 5020	Westar	Invigor 5030	Westar	Invigor 5020	Westar
Continuous C†	27.8 a	58.5 a	22.5 a	42.0 a	57.5 a	85.0 a
C-w	5.8 b	56.3 ab	14.0 a	21.6 b	49.8 a	34.8 b
p-C-w	9.0 b	48.0abc	15.4 a	36.5 a	14.0 b	32.0 bc
C-w-p-w	2.5 b	27.8 c	3.5 b	11.9 bc	9.3 b	16.5 c
C-w-f-w	1.8 b	35.8 bc	4.5 b	7.3 c	7.5 b	21.3 c
LSD $_{(0.05)}$	8.7	21.1	10.2	11.4	16.0	18.0
Mean	9.4 b	45.3 a	12.0 b	23.9 a	27.6 a	37.9 a
LSD $_{(0.05)}$	8.0		6.7		12.1	

† C - canola, P – field pea, W – wheat, F – flax.

Table 6. Blackleg severity [0- 5, low to high rating] in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 -2007.

Rotation	2004				2005			
	Scott		Melfort		Scott		Melfort	
	Invigor 5030	Westar	Invigor 5030	Westar	Invigor 5020	Westar	Invigor 5020	Westar
Continuous C†	0.1	2.6	0.3	3.4	0.5	1.6	.	0.7
C-w	0	1.7	0.3	2.4	0.3	1.7	.	0.8
p-C-w	0.5	1.6	0.2	3.1	0.1	1.2	.	0.3
C-w-p-w	0	1.8	0.1	2.0	0.2	1.4	.	0.3
C-w-f-w	0	1.5	0.1	2.2	0.2	1.5	.	0.4
LSD $_{(0.05)}$	0.7	0.9	0.1	0.7	0.2	0.7	.	0.2
Mean	0.1 b	1.8 a	0.1 b	2.6 a	0.3 b	1.5 a	.	0.5
LSD $_{(0.05)}$	0.3		0.4		0.2			

† C - canola, P – field pea, W – wheat, F – flax.

Table 6 continued. Blackleg severity [0- 5, low to high rating] in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 -2007.

Rotation	2006				2007	
	Scott		Melfort		Scott	
	Invigor 5020	Westar	Invigor 5030	Westar	Invigor 5020	Westar
Continuous C†	0.7 a	1.6 a	0.5 a	1.2 a	1.3 a	2.4 a
C-w	0.1 b	1.3 ab	0.3 b	0.6 b	1.0 a	0.8 b
p-C-w	0.2 b	1.1 abc	0.3 b	1.1a	0.3 b	0.7 b
C-w-p-w	0.1 b	0.6 c	0.1 c	0.3 b	0.1 b	0.4 b
C-w-f-w	0 b	0.8 bc	0.1 c	0.2 b	0.1 b	0.5 b
LSD $_{(0.05)}$	0.3	0.5	0.2	0.4	0.3	0.4
Mean	0.2 b	1.1 a	0.3 b	0.7 a	0.6 b	0.9 a
LSD $_{(0.05)}$	0.2		0.2		0.3	

† C - canola, P – field pea, W – wheat, F – flax.

Table 7. Yield (kg ha^{-1}) in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 - 2007.

Rotation	2004				2005			
	Scott		Melfort		Scott		Melfort	
	Invigor 5030	Westar	Invigor 5030	Westar	Invigor 5020	Westar	Invigor 5020	Westar
Continuous C†	1316 c	858 b	1345 b	824 b	1149 b	743 b	2441 c	1655 b
C-w	1444 bc	758 b	2180 a	969 b	1757 a	1072 a	2545 bc	1686 b
p-C-w	1919 a	1498 a	2163 a	1326 a	1469 ab	1195 a	3086 a	2082 a
C-w-p-w	1802 ab	1417 a	2177 a	1476 a	1555 ab	1011 a	2855 ab	2269 a
C-w-f-w	1717 abc	1486 a	1874 ab	1431 a	1322 ab	1085 a	2701 bc	2080 a
LSD $_{(0.05)}$	436	420	538	261	607	287	258	378
Mean	1640 a	1204 b	1948 a	1205 b	1450 a	1021 b	2726 a	1955 b
LSD $_{(0.05)}$	188		349		153		150	

† C - canola, P – field pea, W – wheat, F – flax.

Table 7 continued. Yield (kg ha^{-1}) in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 - 2007.

Rotation	2006				2007	
	Scott		Melfort		Scott	
	Invigor 5020	Westar	Invigor 5030	Westar	Invigor 5020	Westar
Continuous C†	2189	1347	1787 c	1335 c	1681 bc	1072 b
C-w	2117	1503	2228 b	1326 c	2001 ab	1335 ab
p-C-w	2502	1664	2587 a	1588 b	2057 a	1551 a
C-w-p-w	2537	1435	2111 b	1830 a	2034 a	1563 a
C-w-f-w	2708	1874	2293 a	1793 a	1634 c	1568 a
LSD $_{(0.05)}$	982	536	316	229	345	285
Mean	2410 a	1565 b	2201 a	1574 b	1881 a	1418 b
LSD $_{(0.05)}$	238		159		133	

† C - canola, P – field pea, W – wheat, F – flax.

Table 8. Test weight (kg hl^{-1}) in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 – 2007 .

Rotation	2004				2005			
	Scott		Melfort		Scott		Melfort	
	Invigor 5030	Westar	Invigor 5030	Westar	Invigor 5020	Westar	Invigor 5020	Westar
Continuous C†	69.8	68.4	64.7	62.4	66.3	65.5	63.9	63.0
C-w	69.8	67.8	64.1	63.0	65.5	64.7	63.3	63.2
p-C-w	69.1	68.7	64.5	63.2	65.5	66.2	63.7	63.8
C-w-p-w	68.7	67.3	64.8	63.4	64.7	65.5	63.4	63.4
C-w-f-w	69.6	68.1	64.5	63.4	65.9	65.2	63.1	63.6
LSD $_{(0.05)}$	0.6	0.9	0.5	0.7	1.3	1.9	0.6	0.7
Mean	69.5 a	68.0 b	64.5 a	63.1 b	65.6	65.4	63.5	63.4
LSD $_{(0.05)}$	0.4		0.7		0.6		0.2	

† C - canola, P – field pea, W – wheat, F – flax.

Table 8 continued. Test weight (kg hl^{-1}) in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 – 2007 .

Rotation	2006				2007	
	Scott		Melfort		Scott	
	Invigor 5020	Westar	Invigor 5030	Westar	Invigor 5020	Westar
Continuous C†	66.7	67.3	65.2	66.3 a	65.0	66.9
C-w	66.8	66.8	65.1	66.0 ab	64.6	66.1
p-C-w	66.9	66.6	65.2	66.3 a	64.5	66.4
C-w-p-w	66.5	66.9	65.3	66.0 ab	64.9	66.6
C-w-f-w	69.4	67.3	65.1	65.6 b	66.2	65.6
LSD $_{(0.05)}$	9.5	0.9	0.2	0.5	2.2	1.8
Mean	65.2	67.0	65.2 a	66.0 b	65.1 b	66.3 a
LSD $_{(0.05)}$	2.8		0.2		0.7	

† C - canola, P – field pea, W – wheat, F – flax.

Table 9. Thousand Seed weight (grams) in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 - 2007.

Rotation	2004				2005			
	Scott		Melfort		Scott		Melfort	
	Invigor 5030	Westar	Invigor 5030	Westar	Invigor 5020	Westar	Invigor 5020	Westar
Continuous C†	2.8	2.9 a	2.8	2.7	3.5	3.2	3.3	3.3
C-w	2.9	2.6 b	3.1	2.8	3.7	3.6	3.3	3.5
p-C-w	3.0	3.1 a	3.0	2.9	3.9	3.7	3.4	3.7
C-w-p-w	3.1	2.9 a	3.1	2.9	3.9	3.6	3.4	3.7
C-w-f-w	3.0	3.0 a	3.0	2.8	3.9	3.8	3.3	3.6
LSD $_{(0.05)}$	0.3	0.3	0.2	0.4	0.3	0.3	0.1	0.2
Mean	2.9	2.9	3.0	2.8	3.8 a	3.6 b	3.3 a	3.6 b
LSD $_{(0.05)}$	0.1		0.2		0.1		0.1	

† C - canola, P – field pea, W – wheat, F – flax.

Table 9 continued. Thousand Seed weight (grams) in rotations with Invigor and Westar canola at Scott and Melfort SK during 2004 - 2007.

Rotation	2006				2007	
	Scott		Melfort		Scott	
	Invigor 5020	Westar	Invigor 5030	Westar	Invigor 5020	Westar
Continuous C†	2.8	3.0	3.3	3.9	2.5 ab	2.5 b
C-w	2.9	3.2	3.2	3.8	2.6 a	2.9 a
p-C-w	2.9	3.1	3.3	3.8	2.5 ab	30. a
C-w-p-w	2.9	2.9	3.3	3.8	2.5 ab	3.0 a
C-w-f-w	2.9	3.1	3.2	3.8	2.4 b	3.0 a
LSD $_{(0.05)}$	0.2	0.4			0.2	
Mean	2.9 b	3.1 a	3.3 b	3.8 a	2.5 b	2.9 a
LSD $_{(0.05)}$	0.1		0.1		0.1	

† C - canola, P – field pea, W – wheat, F – flax.

Table 10. Green seed (%) in rotations with Invigor and Westar canola at Scott and Melfort SK. during 2004, 2005 and 2006.

Rotation	2004				2005				2006			
	Scott		Melfort		Scott		Melfort		Scott		Melfort	
	Invigor 5030	Westar	Invigor 5030	Westar	Invigor 5020	Westar	Invigor 5020	Westar	Invigor 5020	Westar	Invigor 5020	Westar
Continuous C†	0.3	0.3	2.0	5.0 b	6.5	4.0	1.4	1.4	8.1 ab	10.4	0.6	2.3 a
C-w	0.6	0.6	2.1	10.0 a	3.5	10.1	0.5	0.7	9.0 ab	11.1	0.6	1.6 ab
p-C-w	0.4	0.4	2.0	6.2 b	3.6	6.0	0.3	0.9	8.6 ab	11.1	0.8	0.8 b
C-w-p-w	0.9	0.5	1.6	6.0 b	3.9	4.6	0.5	1.1	10.9 a	9.1	0.9	1.4 ab
C-w-f-w	0	0.4	1.7	5.5 b	4.9	4.6	1.0	0.4	7.5 b	8.9	0.8	0.9 b
LSD $_{(0.05)}$	0.9	0.7	0.9	2.9	3.9	8.3	1.0	0.8	3.2	4.5	0.8	1.1
Mean	0.4	0.4	1.9 b	6.6 a	4.5	5.9	0.7	0.9	8.8 b	10.1 a	0.7 b	1.4 a
LSD $_{(0.05)}$	0.3		1.5		1.9		0.4		1.2		0.4	

† C - canola, P – field pea, W – wheat, F – flax.

Table 11. Oil content (%) in rotations with Invigor and Westar canola at Scott and Melfort SK. during 2004, 2005 and 2006.

Rotation	2004		2005				2006	
	Scott		Scott		Melfort		Scott	
	Invigor 5030	Westar	Invigor 5020	Westar	Invigor 5020	Westar	Invigor 5020	Westar
Continuous C†	42.9 b	42.1 b	47.7	45.2 b	47.7 a	45.9 b	46.9	41.2
C-w	42.4 b	38.9 c	48.6	45.8 ab	47.3 ab	47.2 ab	46.0	42.6
p-C-w	43.4 b	44.3 ab	48.8	47.0 a	47.0 b	47.6 ab	45.0	43.4
C-w-p-w	45.3 a	42.7 ab	47.9	45.8 ab	47.3 ab	48.2 a	46.3	41.0
C-w-f-w	42.5 b	45.0 a	47.9	46.6 ab	47.1 b	47.9 ab	46.8	42.6
LSD $_{(0.05)}$	1.7	2.3	2.5	1.5	0.5	2.0	1.8	2.7
Mean	43.3	42.6	48.1 a	46.1 b	47.3	47.4	46.2 a	42.2 b
LSD $_{(0.05)}$	1.1		0.7		0.6		0.8	

† C - canola, P – field pea, W – wheat, F – flax.

Table 12. Plant density and weed biomass in pea phases of rotations at Scott and Melfort.

Rotation	Plant density (plants m^{-1})						Weed/Crop Biomass (%)			
	2004		2005		2006		2004		2005	2006
	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott	Melfort	Melfort	Melfort
Continuous P†	85	103	121 ab	84	101	77 a	1.8	6.8	24.3	194.4 a
P-w	93	99	124 a	86	100	63 b	1.5	2.8	2.4	7.1 b
P-c-w	106	105	116 ab	91	103	68 ab	1.4	4.1	19.3	10.6 b
c-w-P-w	99	103	109 b	93	117	70 ab	0.4	2.8	1.0	6.7 b
LSD $_{(0.05)}$	11	12	13	12	22	12	2.3	4.5	40.5	97.6

† C - canola, P – field pea, W – wheat, F – flax.

Table 13. Mycosphaerella blight severity (Xue and Wang scales) in pea phases of rotations at Scott and Melfort SK during 2004, 2005 and 2006.

Rotation	Mycosphaerella blight Xue scale (0-9)						Mycosphaerella blight Wang scale (0-9)					
	2004		2005		2006		2004		2005		2006	
	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott	Melfort
Continuous P†	8.3	8.4 a	-‡	2.4	1.8	1.1	5.8	6.0 a	-‡	3.9 b	2.8	4.8 a
P-w	7.9	6.9 b	-	2.4	1.8	1.5	6.4	4.5 b	-	4.3 b	1.5	3.5 b
P-c-w	8.2	6.9 b	-	3.1	2.3	1.4	6.9	4.7 b	-	5.4 a	2.6	3.4 b
c-w-P-w	7.8	7.3 b	-	2.8	2.6	1.1	6.8	4.6 b	-	5.1 ab	2.6	3.4 b
LSD $_{(0.05)}$	0.8	0.6		0.7	0.8	0.8	1.3	0.8		0.9	1.4	1.1
No Fung.	8.5 a	8.0 a	-	3.1	2.8 a	1.5	6.5	5.7 a	-	5.0	2.9	4.0 a
Fungicide	7.6 b	6.5 b	-	2.4	1.7 b	1.0	6.8	4.1 b	-	4.8	2.0	3.2 b
LSD $_{(0.05)}$	0.3	0.5		0.4	0.6	0.4	0.3	0.5		0.7	1.1	0.6

† C - canola, P – field pea, W – wheat, F – flax. ‡ – hail resulted in damage to foliage confounding disease evaluation

Table 14. Seed yield of field pea phases of rotations at Scott and Melfort SK during 2004-2007.

Rotation	Yield (kg ha^{-1})						
	2004		2005		2006		2007
	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott
Continuous P†	2202	1540 b	835 ab	766 b	1986	1141 b	3070
P-w	2529	2251 a	810 b	2963 a	1859	2964 a	2662
P-c-w	2328	2411a	949 ab	2899 a	1859	3044 a	3161
c-w-P-w	2566	2336 a	1099 b	3003 a	1996	3561 a	3226
LSD $_{(0.05)}$	565	235	289	362	330	555	686
No Fung.	2238 b	1783 b	588 b	2456	1828 b	2531	3035
Fungicide	2601 a	2646 a	1326 a	2722	2023 a	2824	3134
LSD $_{(0.05)}$	202	158	129	548	161	590	163

† C - canola, P – field pea, W – wheat, F – flax.

Table 15. Test weight of field pea phases of rotations at Scott and Melfort SK during 2004-2007.

Rotation	Test weight (kg hl^{-1})						
	2004		2005		2006		2007
	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott
Continuous P†	84.9	78.5 a	74.3	80.3 b	79.0 ab	81.6 b	82.1
P-w	85.1	76.1 b	74.5	81.5 a	79.9 a	83.1 a	82.0
P-c-w	84.8	75.8 b	74.9	81.5 a	78.0 b	83.0 a	84.9
c-w-P-w	84.8	75.5 b	74.4	81.8 a	78.4 b	83.3 a	85.2
LSD $_{(0.05)}$	0.6	0.8	1.4	0.5	1.1	0.4	5.5
No Fung.	85.1	75.8 b	74.2 b	81.1 b	78.8	82.7	84.1
Fungicide	84.7	76.6 a	75.1 a	81.6 a	78.4	83.0	84.0
LSD $_{(0.05)}$	0.6	0.6	0.5	0.4	0.7	0.4	3.6

† C - canola, P – field pea, W – wheat, F – flax.

Table 16. Thousand seed weight (TSW) of field pea phases of rotations at Scott and Melfort SK during 2004-2007.

Rotation	TSW (grams)						
	2004		2005		2006		2007
	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott
Continuous P†	197.2	166.6	186.4	202.4 b	185.6 a	233.6 b	189.1
P-w	201.5	165.4	181.0	210.0 a	174.7 b	250.6 a	192.1
P-c-w	200.0	164.7	184.3	212.4 a	172.0 b	248.3 a	185.5
c-w-P-w	202.3	163.8	178.7	211.9 a	173.6 b	251.6 a	183.9
LSD $_{(0.05)}$	10.1	6.6	17.0	7.5	9.0	5.5	15.1
No Fung.	196.8 b	153.4 b	169.1 b	207.8	176.8	244.3	186.3
Fungicide	204.3 a	176.2 a	195.3 a	212.5	173.7	250.3	187.1
LSD $_{(0.05)}$	4.0	5.3	5.9	5.1	8.9	4.5	2.1

† C - canola, P – field pea, W – wheat, F – flax.

Table 17. Protein content (%) of field pea phases of rotations at Scott and Melfort SK during 2004-2007.

Rotation	Protein (%)						
	2004		2005		2006		2007
	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott
Continuous P†	26.2	24.7	26.4	22.1 a	24.4	22.4	27.7
P-w	25.9	24.2	26.6	21.0 b	24.3	21.8	28.2
P-c-w	26.0	24.6	26.5	21.0 b	24.9	21.8	27.2
c-w-P-w	25.5	24.5	26.4	21.3 b	24.6	21.9	27.4
LSD $_{(0.05)}$	0.9	0.5	0.5	0.5	0.9	0.5	1.2
No Fung.	26.2 a	25.2 a	27.1 a	21.5 a	24.7	22.0	27.6
Fungicide	25.5 b	23.9 b	25.8 b	21.1 b	24.6	21.9	27.4
LSD $_{(0.05)}$	0.4	0.3	0.2	0.2	0.4	0.3	0.5

† C - canola, P – field pea, W – wheat, F – flax.

Table 18. Wheat leaf spot severity in several rotations at Melfort SK, during 2004-06. Bolded numbers indicate significant differences (P< 0.05).

Site year	Fungicide treatment	Rotation†								
		c-W	p-W	p-c-W	c-W-p-w	c-w-p-W	c-W-f-w	c-w-f-W	Mean	LSD (0.05)
		Leaf spot severity of the flag and penultimate leaves (%)								
2004	No	**44.0**	**53.2**	**47.4**	**41.3**	**51.6**	**40.0**	**58.1**	**47.3**	
	Yes	**16.4**	**15.4**	**18.4**	**23.5**	**14.0**	**16.4**	**20.0**	**17.9**	
	LSD (0.05)	8.0	12.5	6.1	17.2	5.2	10.6	6.9	3.9	
	mean	30.2	34.3	32.9	32.0	32.5	28.2	39.1		6.2
2005	No	**51.1**	**58.8**	**60.9**	**49.1**	**50.0**	**41.4**	**61.5**	**53.3**	
	Yes	**11.0**	**10.0**	**6.3**	**10.7**	**10.0**	**9.5**	**9.9**	**9.6**	
	LSD (0.05)	10.0	11.9	10.1	9.0	8.0	15.1	8.8	2.9	
	mean	31.1	34.4	33.6	29.9	30.0	25.4	35.7		5.5
2006	No	**15.5**	19.5	**16.9**	**17.4**	**28.4**	**17.9**	**19.5**	**19.3**	
	Yes	**4.2**	2.6	**5.1**	**3.6**	**3.2**	**2.6**	**2.6**	**3.4**	
	LSD (0.05)	9.6	17.3	13.3	6.3	11.2	5.9	13.7	3.0	
	mean	9.9	11.1	11.0	10.5	15.8	10.2	11.1		5.7
		Leaf spot severity on the whole plant (0-11)								
2004	No	**10.2**	**10.7**	**10.3**	**9.8**	**10.6**	**9.7**	**10.9**	**10.3**	
	Yes	**7.8**	**7.6**	**8.3**	**8.3**	**7.4**	**7.5**	**8.1**	**7.9**	
	LSD (0.05)	0.7	0.9	0.9	1.3	0.6	0.9	0.9	0.3	
	mean	9.0	9.1	9.3	9.0	9.0	8.6	9.5		0.5
2005	No	**10.0**	**10.5**	**10.6**	**9.5**	**9.9**	**8.9**	**8.0**	**9.6**	
	Yes	**5.6**	**5.3**	**4.6**	**5.6**	**5.5**	**5.4**	**3.5**	**5.1**	
	LSD (0.05)	1.0	2.4	0.9	1.0	0.8	1.7	0.8	0.3	
	mean	7.8	7.6	7.6	7.6	7.7	7.1	8.0		0.5
2006	No	**6.4**	**7.8**	**6.5**	**6.9**	**7.8**	**7.0**	**6.6**	**7.0**	
	Yes	**3.5**	**2.8**	**3.4**	**3.8**	**3.4**	**3.0**	**3.1**	**3.3**	
	LSD (0.05)	2.6	2.3	2.7	2.2	1.1	1.0	1.1	0.4	
	mean	5.0	5.3	5.0	5.3	5.6	5.0	4.9		0.8

† C - canola, P – field pea, W – wheat, F – flax.

Table 19. Wheat grain yield (kg ha^{-1}) in several rotations at Scott and Melfort SK, during 2004-06. Bolded numbers indicate significant differences (P< 0.05).

Year	Location	Fungicide treatment	Rotation† c-W	p-W	p-c-W	c-W-p-w	c-w-p-W	c-W-f-w	c-w-f-W	Mean	LSD $_{(0.05)}$
2004	Scott	No	2217	2098	1735	2111	2355	1416	2680	2087	
		Yes	1937	2203	1951	2241	2643	2029	2052	2147	
		LSD $_{(0.05)}$	360	730	801	349	828	824	745	240	
		mean	2077	2150	1843	2176	2499	1723	2366		804
	Melfort	No	2915	3259	3041	2946	**3216**	2925	3409	3084	
		Yes	2820	3302	3165	2865	**3425**	2850	3701	3150	
		LSD $_{(0.05)}$	346	481	237	391	160	199	467	172	
		mean	**2868**	**3281**	**3103**	**2885**	**3324**	**2888**	**3555**		351
2005	Scott	No	**1875**	**2230**	**2053**	**2002**	**2175**	**2098**	**2008**	**2050**	
		Yes	**2438**	**2628**	**2688**	**2518**	**2785**	**2590**	**2556**	**2598**	
		LSD $_{(0.05)}$	321	346	361	476	190	438	278	124	
		mean	2157	2429	2371	2260	2480	2344	2282		382
	Melfort	No	**3583**	3593	**3768**	**3521**	**3474**	**3256**	3139	**3453**	
		Yes	**3996**	4003	**4193**	**3947**	**4092**	**3756**	3376	**3901**	
		LSD $_{(0.05)}$	159	662	292	68	76	411	434	122	
		mean	3790	3785	3935	3739	3783	3506	3258		236
2006	Scott	No	2828	2121	2573	2624	2649	2401	2116	2500	
		Yes	2462	2136	2558	2476	2936	2271	2158	2450	
		LSD $_{(0.05)}$	529	838	888	808	753	926	779	277	
		mean	2645	2129	2566	2550	2793	2336	2163		722
	Melfort	No	4093	4322	4355	4235	4436	4161	3825	4195	
		Yes	4171	4404	4243	4307	4312	4184	3684	4169	
		LSD $_{(0.05)}$	204	256	221	197	238	256	200	102	
		mean	4132	4363	4299	4272	4374	4172	3754		197
2007	Scott	No	2910	3054	2981	2909	3568	3156	3168	3111	
		Yes	2987	3138	3122	3140	3599	3171	3479	3241	
		LSD $_{(0.05)}$	495	269	522	367	496	541	528	172	
		mean	**2949**	**3096**	**3052**	**3025**	**3583**	**3164**	**3323**		310

† C - canola, P – field pea, W – wheat, F – flax.

Table 20. Wheat grain yield, test weight and protein content following Invigor (Inv) or Westar (Wes) canola in several rotations at Scott and Melfort SK, during 2004-06. Bolded numbers indicate significant differences (P< 0.05).

Year	Location	Grain yield (kg ha^{-1}) Inv	Wes	LSD	Test wt (kg hl^{-1}) Inv	Wes	LSD	Protein content (%) Inv	Wes	LSD
2004	Scott	2128	2100	307	74.5	74.9	0.8	16.3	16.4	0.3
	Melfort	3078	3129	178	70.7	70.9	0.5	**12.8**	**13.0**	0.2
2005	Scott	**2163**	**2403**	222	75.3	76.3	0.8	14.9	15.1	0.3
	Melfort	**3599**	**3884**	172	**74.7**	**74.9**	0.2	**13.2**	**14.1**	0.2
2006	Scott	2521	2487	311	**73.8**	**73.2**	0.5	16.0	16.0	0.3
	Melfort	4111	4224	200	40.5	40.5	0.3	12.8	13.1	0.5
2007	Scott	3218	3147	191	74.7	74.8	0.8	15.0	15.4	0.4

Table 21. Wheat test weight (kg hl^{-1}) in several rotations at Scott and Melfort SK, during 2004-06. Bolded numbers indicate significant differences (P< 0.05).

Year	Location	Fungicide treatment	Rotation†							Mean	LSD $_{(0.05)}$
			c-W	p-W	p-c-W	c-W-p-w	c-w-p-W	c-W-f-w	c-w-f-W		
2004	Scott	No	74.7	75.2	74.0	74.1	76.0	73.1	75.8	74.7	
		Yes	73.9	75.9	74.4	74.6	76.0	74.1	73.3	74.8	
		LSD $_{(0.05)}$	1.7	1.9	2.1	1.1	1.6	2.1	1.6	0.6	
		mean	**74.3**	**75.6**	**74.2**	**74.4**	**76.0**	**73.6**	**75.6**		1.9
	Melfort	No	70.4	70.8	71.2	70.1	70.7	70.0	71.8	70.7	
		Yes	69.6	70.6	71.4	70.4	71.2	70.4	72.0	70.8	
		LSD $_{(0.05)}$	0.9	1.7	0.8	1.1	1.1	0.7	0.5	0.4	
		mean	70.0	70.7	71.3	70.2	71.0	70.2	70.9		1.0
2005	Scott	No	**74.4**	75.8	75.3	**74.8**	75.2	**75.1**	74.5	**75.0**	
		Yes	**76.5**	76.1	76.0	**77.1**	76.2	**77.2**	76.0	**76.4**	
		LSD $_{(0.05)}$	1.2	2.6	1.5	2.1	1.2	1.7	1.5	0.6	
		mean	75.4	75.9	75.6	76.0	75.7	76.1	75.2		1.0
	Melfort	No	74.8	75.0	74.2	75.1	74.9	74.6	74.3	74.7	
		Yes	74.9	74.6	74.4	75.3	75.0	75.0	74.3	74.8	
		LSD $_{(0.05)}$	0.3	0.9	0.3	0.4	0.5	0.5	0.4	0.2	
		mean	**74.8**	**74.8**	**74.3**	**75.2**	**75.0**	**74.9**	**74.3**		0.3
2006	Scott	No	73.1	72.9	73.4	73.5	**72.1**	73.7	74.0	**73.2**	
		Yes	73.1	73.3	73.6	74.3	**73.6**	73.3	74.5	**73.7**	
		LSD $_{(0.05)}$	1.3	2.3	1.1	1.3	1.3	1.4	0.7	0.4	
		mean	**73.1**	**73.1**	**73.5**	**73.9**	**72.9**	**73.6**	**74.3**		0.9
	Melfort	No	79.1	78.8	79.1	**78.9**	**78.9**	**78.8**	78.3	**78.8**	
		Yes	79.1	79.2	79.3	**79.3**	**79.2**	**79.1**	79.1	**79.2**	
		LSD $_{(0.05)}$	0.3	0.7	0.4	0.3	0.3	0.3	0.5	0.1	
		mean	**79.1**	**79.0**	**79.2**	**79.1**	**79.1**	**79.0**	**78.5**		0.3
2006	Scott	No	73.5	74.1	73.7	**74.0**	75.9	74.7	74.3	**74.3**	
		Yes	73.9	74.5	74.8	**75.6**	75.6	75.4	75.5	**75.1**	
		LSD $_{(0.05)}$	1.7	0.8	1.9	1.6	2.0	2.8	2.6	0.7	
		mean	**73.7**	**74.3**	**74.3**	**74.8**	**75.8**	**75.0**	**75.0**		1.7

† C - canola, P – field pea, W – wheat, F – flax.

Table 22. Wheat seed weight (mg) in several rotations at Scott and Melfort SK, during 2004-06. Bolded numbers indicate significant differences (P< 0.05).

Year	Location	Fungicide treatment	Rotation† c-W	p-W	p-c-W	c-W-p-w	c-w-p-W	c-W-f-w	c-w-f-W	Mean	LSD (0.05)
2004	Scott	No	23.7	**23.4**	22.7	23.3	24.6	21.5	24.9	23.4	
		Yes	22.6	**25.2**	23.2	23.7	25.4	23.1	23.6	23.7	
		LSD (0.05)	1.5	0.5	2.3	1.3	2.3	2.8	2.1	0.7	
		mean	23.2	24.3	23.0	23.5	25.0	22.3	24.2		2.6
	Melfort	No	32.4	33.5	32.5	32.1	33.2	32.0	34.1	32.8	
		Yes	31.7	32.8	33.2	31.7	33.4	32.5	35.2	33.0	
		LSD (0.05)	0.8	3.0	1.5	1.7	2.0	1.9	1.4	0.6	
		mean	32.0	33.1	32.8	31.9	33.3	32.2	34.7		1.6
2005	Scott	No	**29.3**	**31.3**	**30.3**	**30.1**	**30.7**	**30.5**	**30.7**	**30.3**	
		Yes	**32.9**	**34.2**	**33.6**	**33.8**	**34.5**	**33.4**	**33.9**	**33.7**	
		LSD (0.05)	1.1	2.3	1.8	2.0	0.8	1.7	1.2	0.5	
		mean	31.1	32.7	32.0	32.0	32.7	32.0	32.3		1.4
	Melfort	No	**36.1**	36.2	**36.5**	36.7	**36.4**	**35.9**	**36.3**	**36.3**	
		Yes	**37.5**	37.6	**38.2**	37.5	**37.6**	**38.0**	**37.9**	**37.7**	
		LSD (0.05)	0.7	1.6	1.0	1.0	1.2	0.7	1.3	0.3	
		mean	36.8	36.6	37.4	37.1	37.0	36.9	37.1		0.6
2006	Scott	No	24.3	23.9	24.2	24.4	24.2	24.6	24.2	24.3	
		Yes	24.0	24.0	23.9	24.8	24.8	24.4	24.6	24.4	
		LSD (0.05)	1.3	1.7	1.2	1.2	1.1	1.3	1.0	0.4	
		mean	24.2	24.0	24.1	24.6	24.5	24.5	24.4		1.4
	Melfort	No	40.3	41.4	40.8	40.2	41.0	40.2	39.1	40.4	
		Yes	40.9	41.8	41.5	40.7	41.8	40.4	39.3	40.8	
		LSD (0.05)	0.9	0.8	0.7	0.8	0.8	0.7	0.5	0.4	
		mean	40.6	41.6	41.2	40.5	41.4	40.3	39.2		0.8
2007	Scott	No	25.2	26.7	25.9	28.3	29.8	27.5	26.7	**27.0**	
		Yes	26.6	28.7	27.1	23.3	30.4	28.3	28.7	**28.3**	
		LSD (0.05)	2.3	6.9	3.8	3.6	3.5	4.1	3.3	1.2	
		mean	**25.9**	**27.7**	**26.5**	**27.5**	**30.1**	**27.9**	**27.7**		2.6

† C - canola, P – field pea, W – wheat, F – flax.

Table 23. Wheat protein content (%) in several rotations at Scott and Melfort SK, during 2004-06. Bolded numbers indicate significant differences (P< 0.05).

Year	Location	Fungicide treatment	Rotation†							Mean	LSD (0.05)
			c-W	p-W	p-c-W	c-W-p-w	c-w-p-W	c-W-f-w	c-w-f-W		
2004	Scott	No	**16.3**	16.0	16.6	16.5	16.0	17.0	15.8	16.3	
		Yes	**16.8**	15.9	16.3	16.4	16.0	16.5	16.2	16.3	
		LSD (0.05)	0.5	0.8	1.0	0.5	0.8	0.9	0.9	0.3	
		mean	16.5	15.9	16.4	16.4	16.0	16.7	16.0		0.9
	Melfort	No	12.9	12.8	13.0	12.8	13.0	12.9	13.	12.9	
		Yes	12.7	12.5	13.0	12.3	13.1	12.9	13.1	12.9	
		LSD (0.05)	0.5	0.5	0.5	0.5	0.2	0.5	0.3	0.2	
		mean	12.8	12.7	13.0	12.5	13.1	12.9	13.1		0.5
2005	Scott	No	15.1	**14.9**	15.2	14.7	14.9	14.6	15.0	**14.9**	
		Yes	15.5	**15.2**	15.4	14.7	15.1	15.2	15.3	**15.2**	
		LSD (0.05)	0.5	0.2	0.3	0.6	0.4	0.7	0.6	0.3	
		mean	**15.3**	**15.0**	**15.3**	**14.7**	**15.0**	**14.9**	**15.2**		0.4
	Melfort	No	13.7	14.3	14.0	13.6	14.3	13.8	13.7	13.9	
		Yes	13.6	14.6	13.9	13.6	14.3	13.4	13.6	13.9	
		LSD (0.05)	0.6	1.0	0.9	0.6	0.7	0.8	0.7	0.3	
		mean	**13.7**	**14.4**	**14.0**	**13.6**	**14.3**	**13.6**	**13.7**		0.4
2006	Scott	No	16.2	16.0	16.0	16.1	16.0	16.3	15.7	15.9	
		Yes	16.3	16.0	16.1	15.9	16.1	15.8	15.5	16.0	
		LSD (0.05)	0.3	0.2	0.7	0.5	0.6	0.9	0.5	0.2	
		mean	16.3	16.0	16.1	16.0	16.1	16.1	15.6		0.7
	Melfort	No	13.3	13.9	13.7	12.6	**14.1**	12.6	12.3	13.1	
		Yes	12.7	13.5	13.2	12.9	**13.4**	12.5	12.0	12.9	
		LSD (0.05)	0.6	0.8	0.5	0.3	0.3	0.5	0.3	0.3	
		mean	**13.0**	**13.7**	**13.5**	**12.8**	**13.8**	**12.6**	**12.2**		0.6
2007	Scott	No	15.1	14.8	16.0	**15.5**	15.1	15.1	15.2	15.3	
		Yes	15.4	15.3	15.7	**14.4**	14.9	15.0	14.9	15.0	
		LSD (0.05)	1.1	0.9	1.0	0.9	0.8	0.8	1.2	0.4	
		mean	15.3	15.0	15.9	14.9	15.0	15.0	15.1		1.1

† C - canola, P – field pea, W – wheat, F – flax.

Table 24. Seed yield of flax in the 4-year rotation (canola-wheat-Flax-wheat) at Scott and Melfort SK during 2004-2007.

Fungicide treatment	Yield (kg ha^{-1})						
	2004		2005		2006		2007
	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott
No	764	891	1165	2068	1833	1302	1260
Yes	891	928	1229	2358	1607	1423	1174
LSD $_{(0.05)}$	384	174	223	505	509	307	196

† C - canola, P – field pea, W – wheat, F – flax.

Table 25. Test weight of flax in the 4-year rotation (canola-wheat-Flax-wheat) at Scott and Melfort SK during 2004-2007.

Fungicide treatment	Yield (kg ha^{-1})						
	2004		2005		2006		2007
	Scott	Melfort	Scott	Melfort	Scott	Melfort	Scott
No	67.4	59.0	68.5	68.3	63.4	70.2	68.7
Yes	67.1	59.7	69.2	67.8	63.6	70.8	69.1
LSD $_{(0.05)}$	0.5	2.4	0.7	0.5	0.5	1.1	0.6

† C - canola, P – field pea, W – wheat, F – flax.

APPENDIX 1

DISEASE ASSESSMENT SCALES

BLACKLEG OF CANOLA

NEWMAN SCALE: (with slight modification)

Disease Score	Lesion circumference
0	No infection
1	<25% girdling of basal stem by lesion
2	25-50%
3	50-75%
4	75-100%
5	Plant dead due to infection

MYCOSPHAERELLA BLIGHT OF FIELD PEA

XUE SCALE:

	Plant Position		
Disease severity	Upper	Middle	Lower
0	F†	F	F
1	F	F	L
2	F	F	M
3	F	L	M
4	L	L	M
5	L	M	M
6	L	M	S
7	M	M	S
8	M	S	S
9	S	S	S

† F - free of disease on leaves/stems; L - light infection, 1-20% of leaves/stems showing symptoms; M – moderate infection 21-50%; S - severe infection, 51-100%.

WANG SCALE:

Stem infection rating for ascochyta foot rot phase of mycosphaerella blight in field pea (leaves not considered).

Stem infection rating	Extent of disease development on the main stem
0	No visible symptoms
1	Small flecks
3	Few large lesions
5	Many large lesions
7	Main stem girdled
9	Plant dead

LEAF SPOT DISEASES OF WHEAT

McFADDEN SCALE:

	Intensity of foliar symptoms on leaves											
Leaf level	0	1	2	3	4	5	6	7	8	9	10	11
Upper	0†	0	0	0	0	0	0	0-1	2-5	6-10	11-25	26-50
Middle	0	0	0	0	0-1	2-5	6-10	6-10	11-25	26-50	>50	>50
Lower	0	0-1	2-5	6-10	11-25	26-50	>50	>50	>50	>50	>50	>50

† percentage of leaf area with lesions in the upper, middle and lower leaf canopies

APPENDIX 2

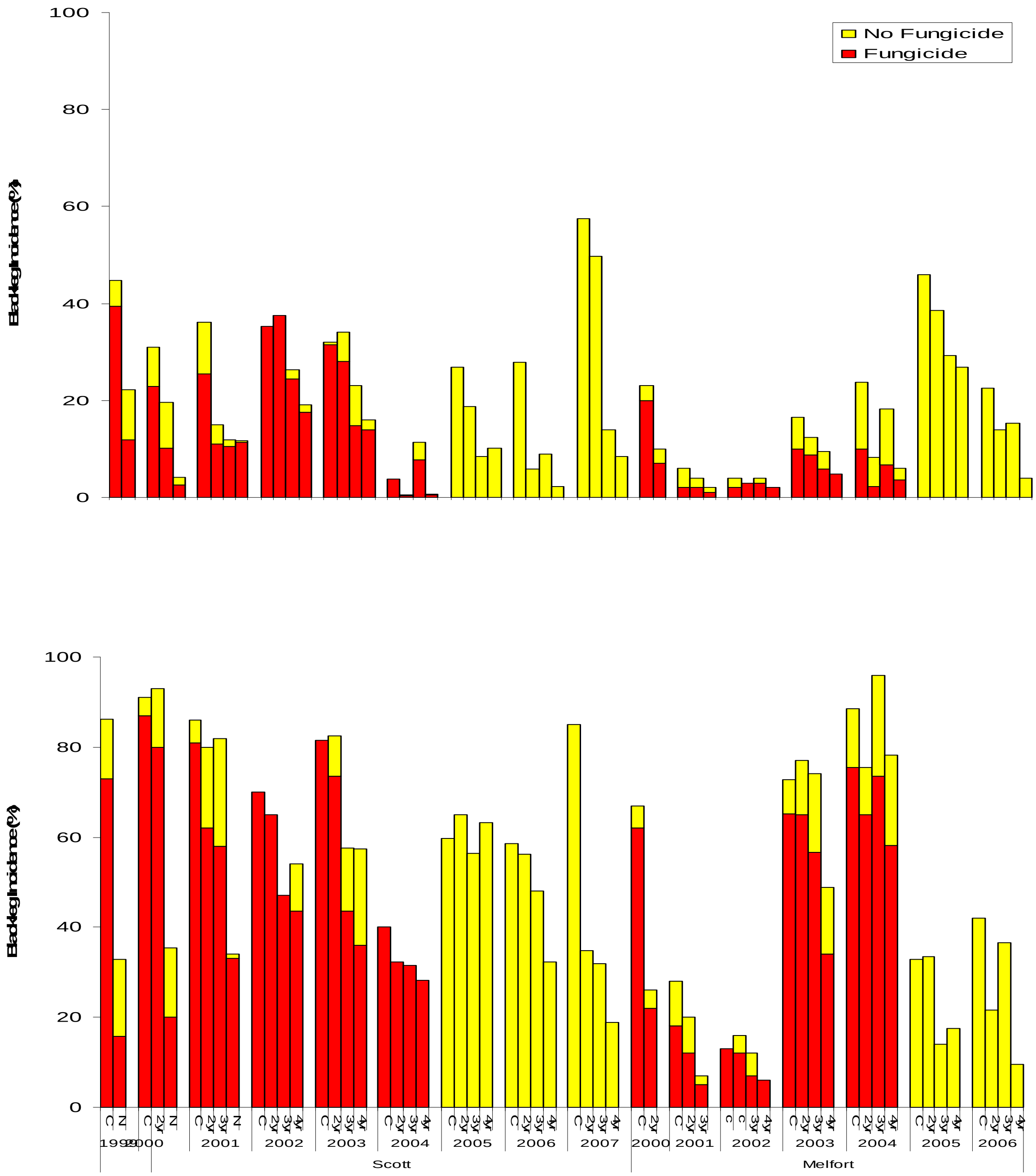

Figure 1. Incidence of blackleg in Hybrid (upper chart) and Westar (lower chart) canola at Scott and Melfort, SK from 1999 to 2007. C – continuous canola, N – never before seeded to canola, 2-, 3- and 4-year rotations (cropping history of Melfort site was canola in 1997 and wheat in 1998) with and without fungicide.

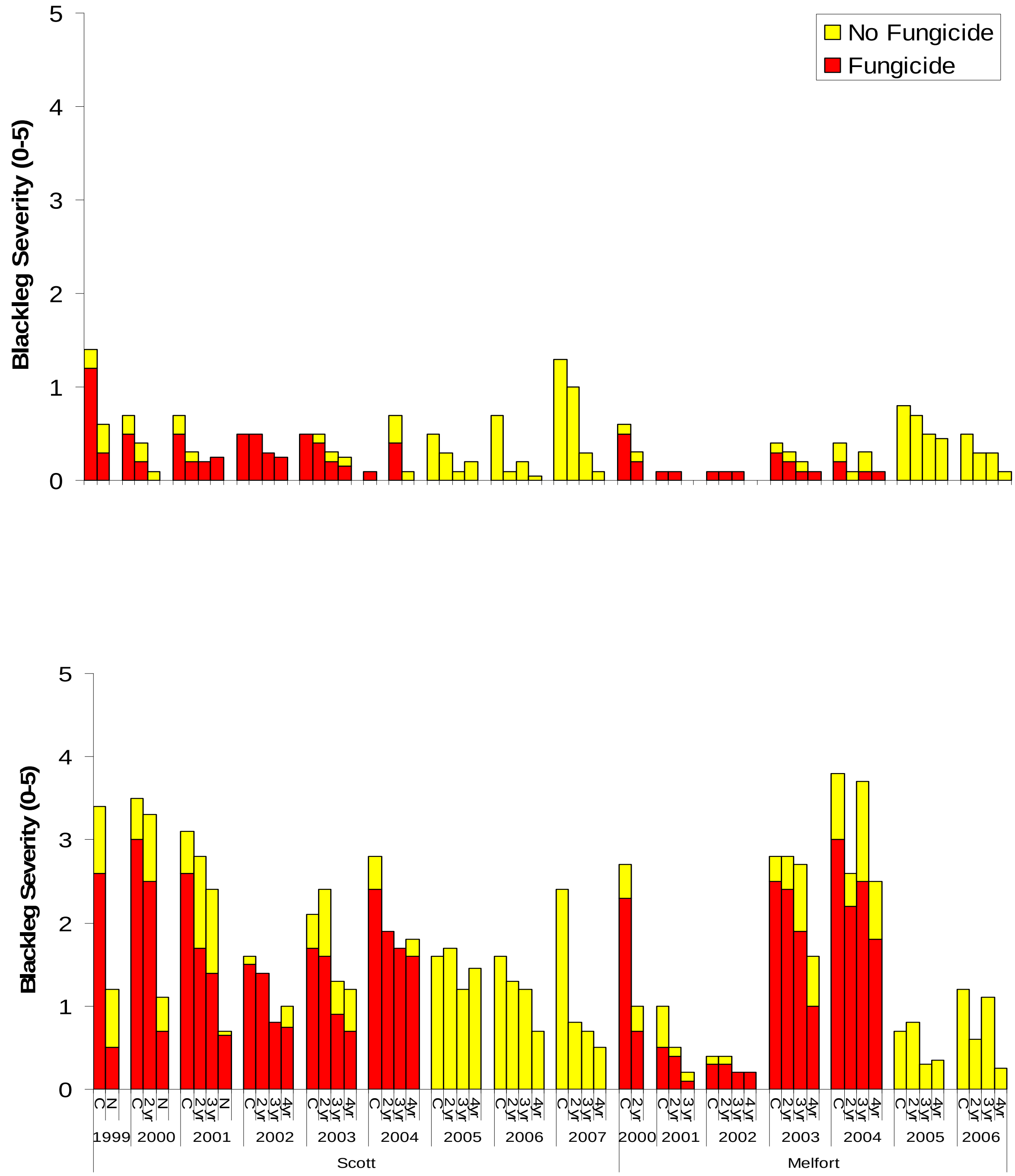

Figure 2. Severity of blackleg (0-5 scale) on Hybrid (upper chart) and Westar (lower chart) canola at Scott and Melfort, SK from 1999 to 2006. C – continuous canola, N – never before seeded to canola, 2-, 3- and 4-year rotations (cropping history of Melfort site was canola in 1997 and wheat in 1998) with and without fungicide.

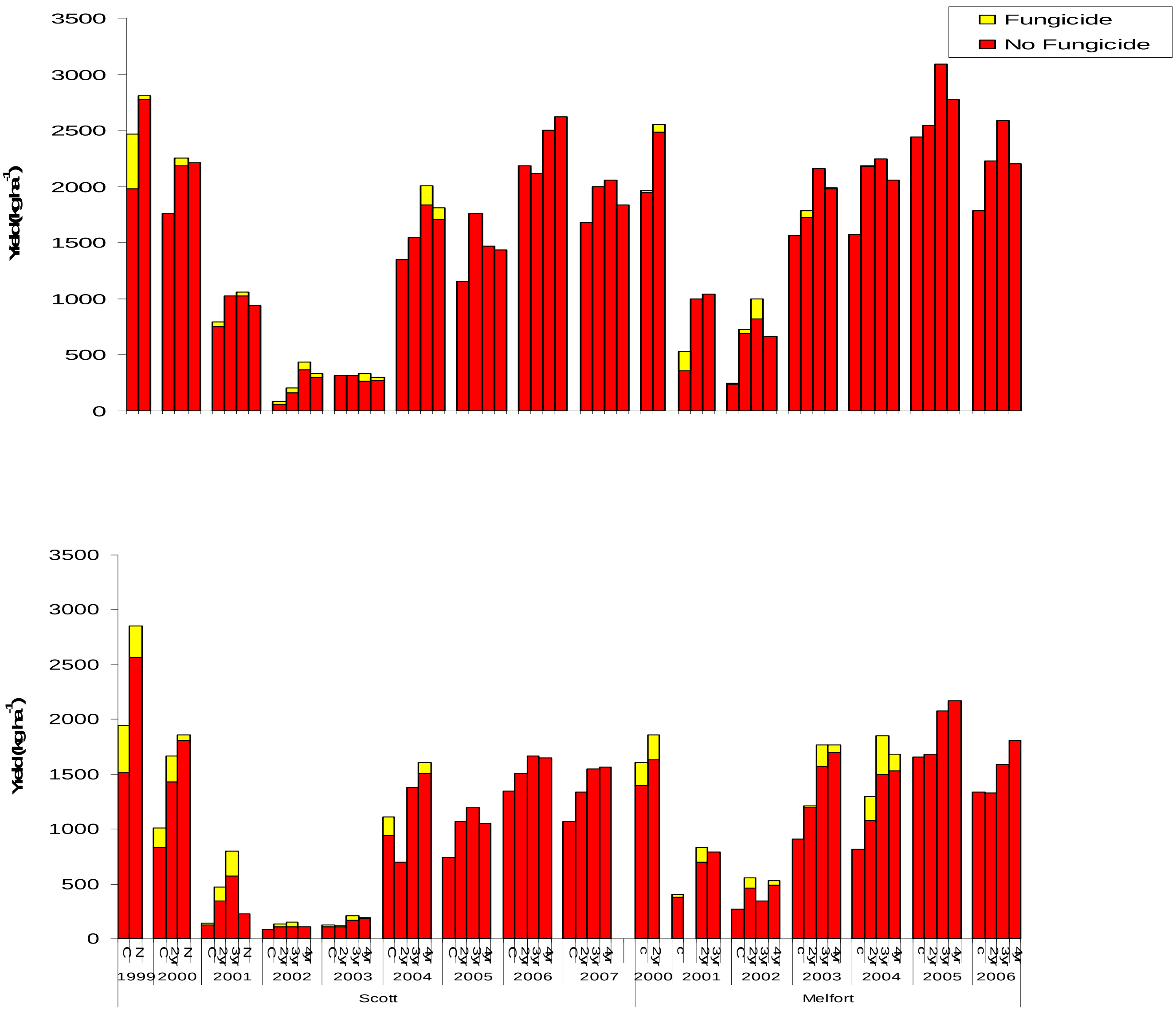

Figure 3. Yield of Hybrid (upper chart) and Westar (lower chart) canola at Scott and Melfort, SK from 1999 to 2006. C – continuous canola, N – never before seeded to canola, 2-, 3- and 4-year rotations (cropping history of Melfort site was canola in 1997 and wheat in 1998) with and without fungicide. In 2004, 2005 and 2006, fungicide applied only to control sclerotinia stem rot, which was observed only at trace levels.

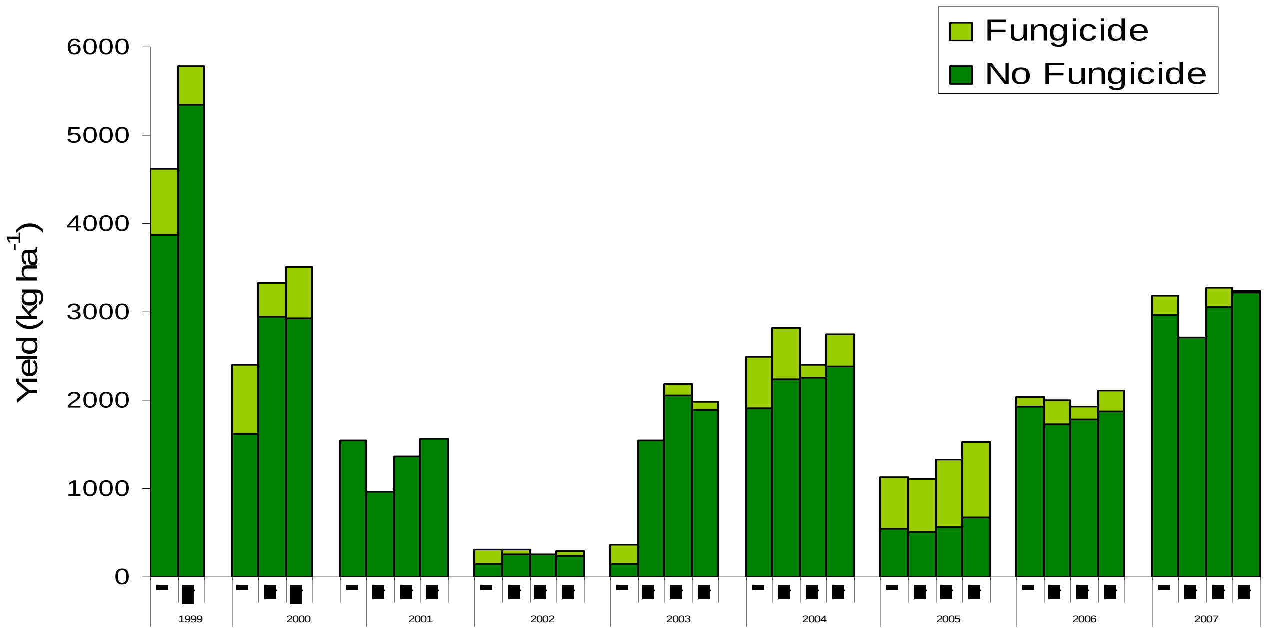

Figure 4. Yield of field pea at Scott, SK under various rotations (C – continuous field pea, and field pea every 2-, 3- and 4-years) with and without fungicide. Varieties Highlight (1998-2000), CDC Mozart (2002-2004) and Eclipse (2006-2007).

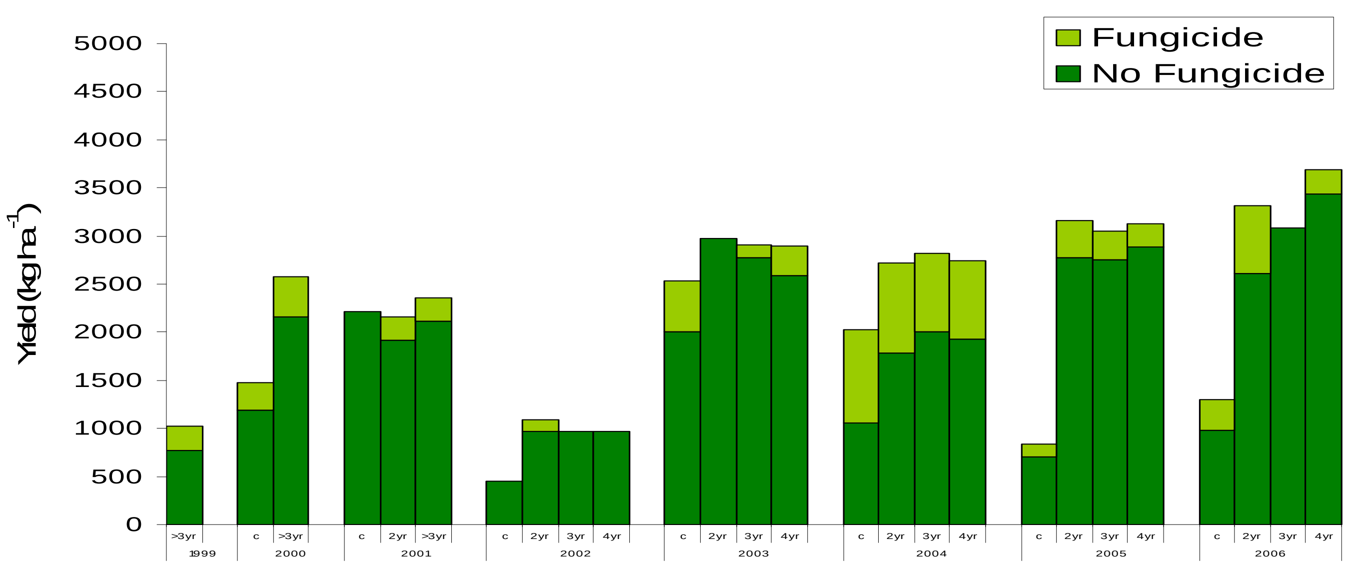

Figure 5. Yield of field pea at Melfort, SK under various rotations (C – continuous field pea, and field pea every 2-, 3- and 4-years) with and without fungicide. Varieties Highlight (1998-2000), CDC Mozart (2002-2004) and Eclipse (2006).

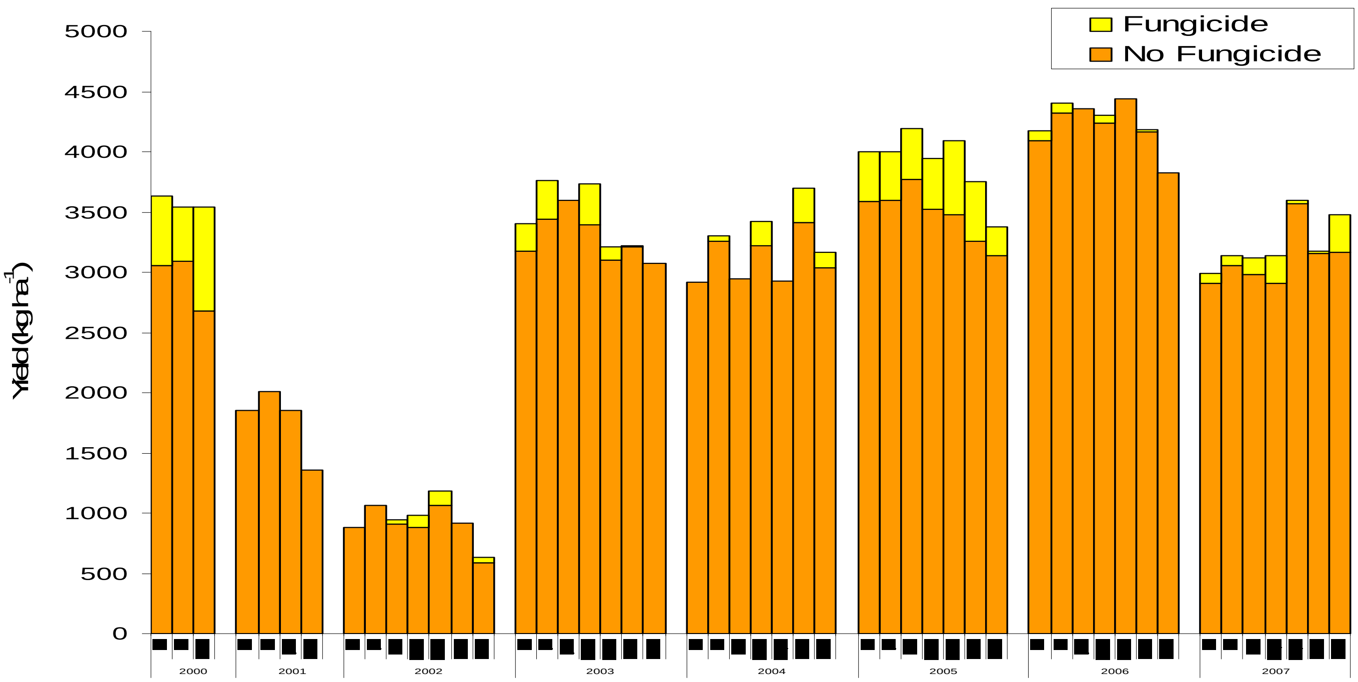

Figure 6. Yield of wheat at Scott, SK under various rotations with and without fungicide (Tilt – 2000 – 2003 and Headline -2004 – 2005). Varieties AC Barrie (1998-2000) and McKenzie (2001), AC Abbey (2002 – 2003) and AC Etonia (2004 – 2006 - 2007).

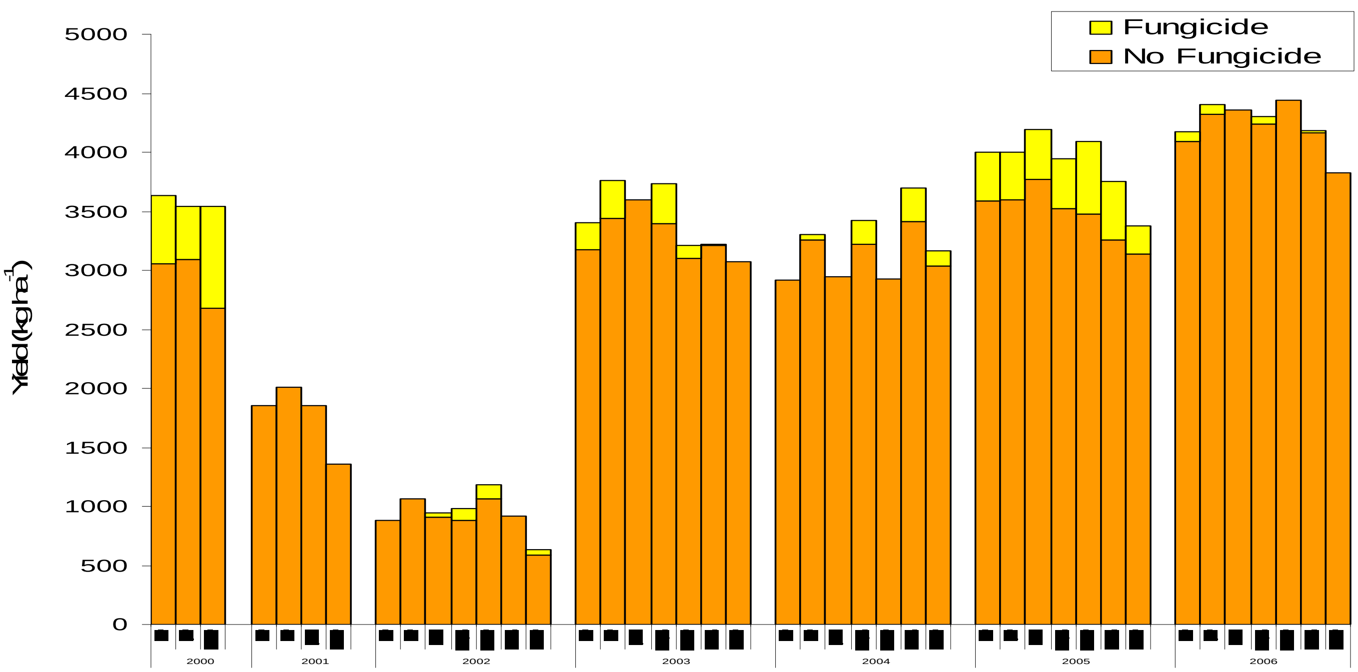

Figure 7. Yield of wheat at Melfort, SK under various rotations with and without fungicide (Tilt – 2000 – 2003 and Headline -2004 – 2005). Varieties AC Barrie (1998-2002) and AC Intrepid (2004-2006).

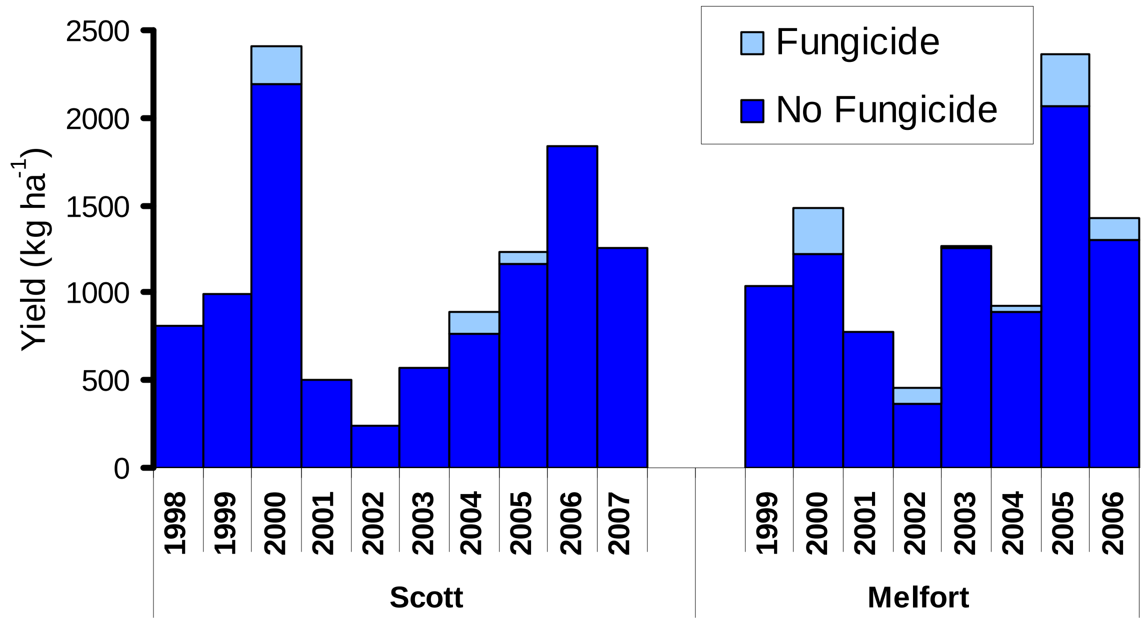

Figure 8. Yield of flax at Scott and Melfort, SK in the 4-year rotation with and without fungicide (Quadris 1998 – 2003 and Headline 2004 - 2006). Varieties: Normandy (1998), Normandy at Melfort and Flanders at Scott (1999), Norlin (2000 – 2003) and Bethune (2004 - 2007).